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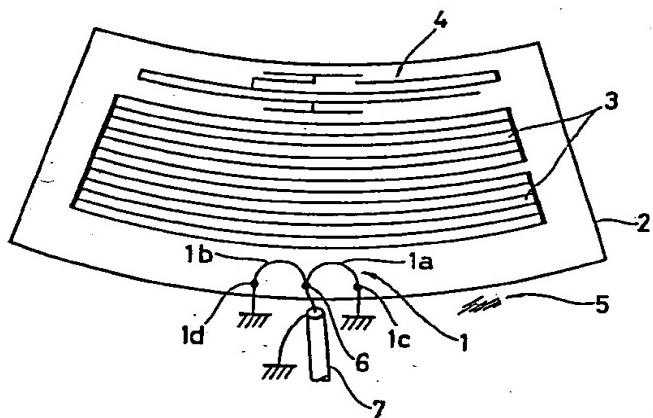
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## (54) A window antenna for a vehicle

(57) A window antenna (1) has a pair of semi-loop antenna elements (1a, 1b) having a length of  $\lambda/2$  which are branched from a power feed point (6) along a grounded conductor portion (5) of the vehicle. The remote ends (1c, 1d) are grounded, and the feed (7) is unbalanced. The antenna 1 has transmission/reception characteristics in a UHF band, for vehicle telephone or personal radio communication set use.

FIG. 1

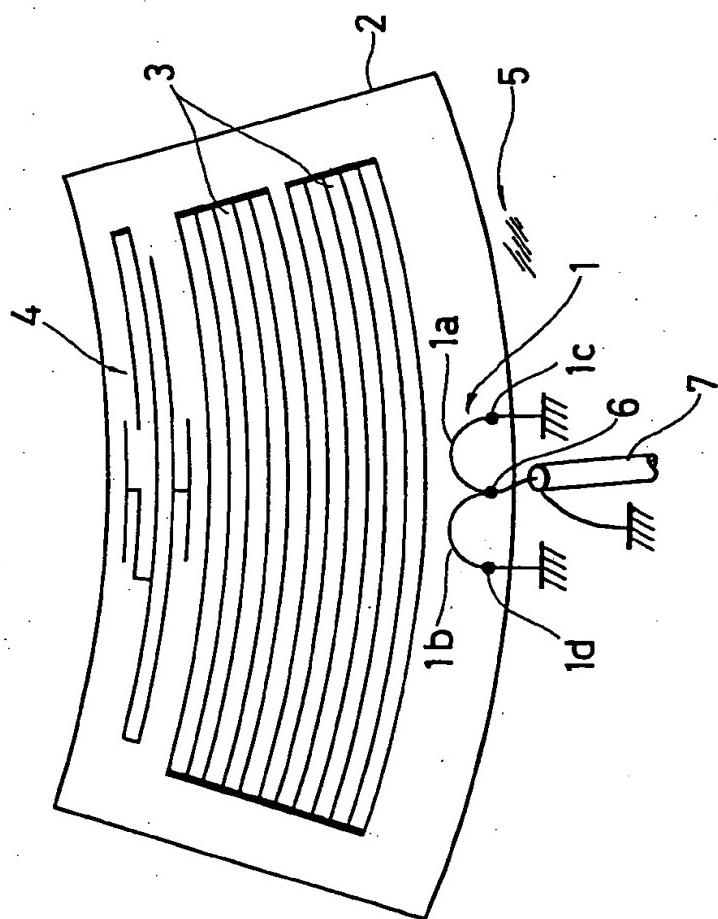


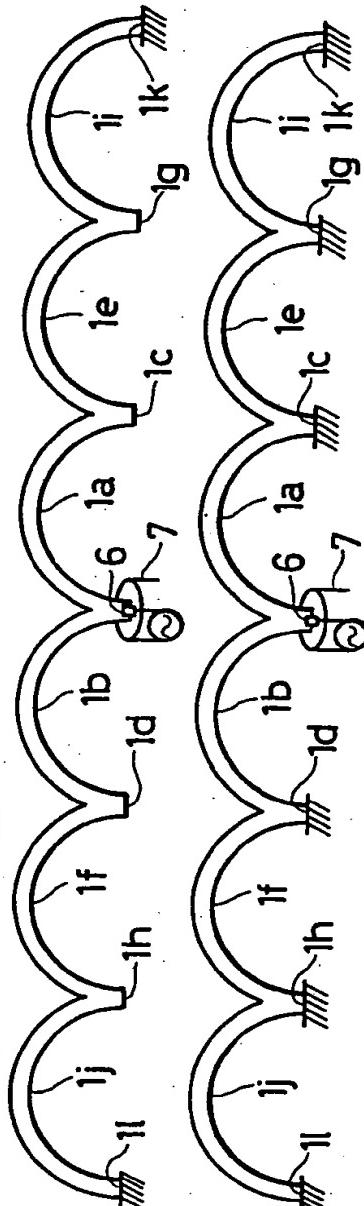
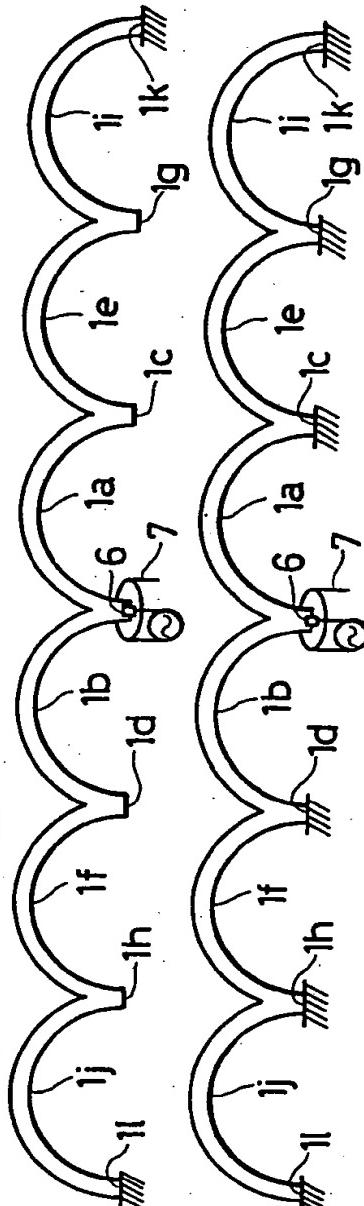
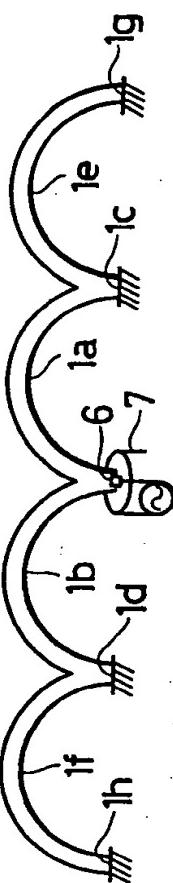
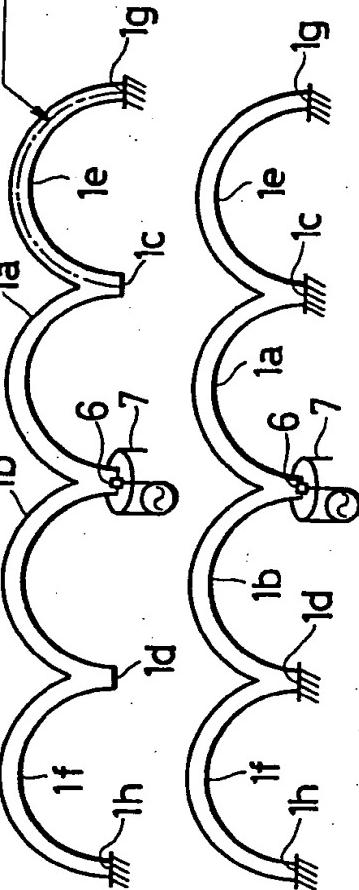
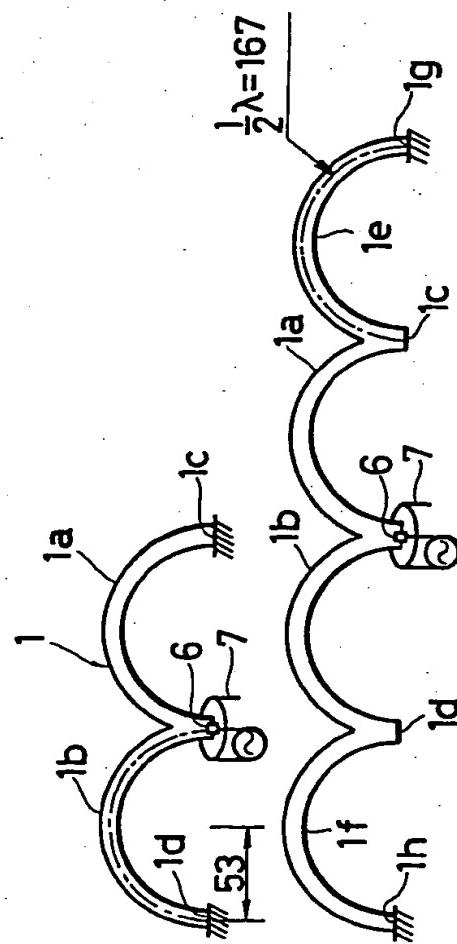
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FIG. I

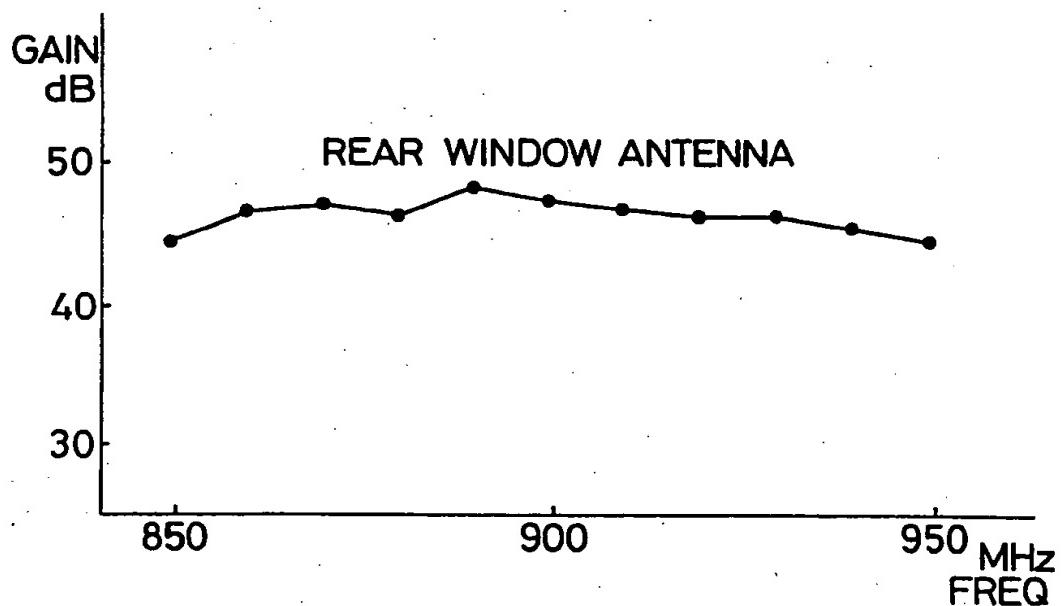




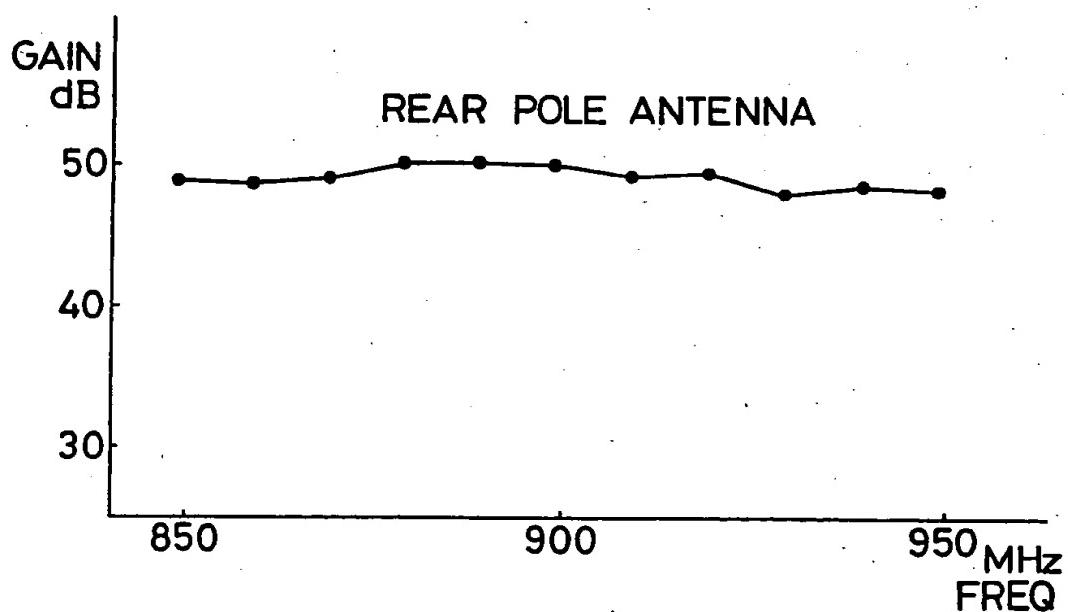
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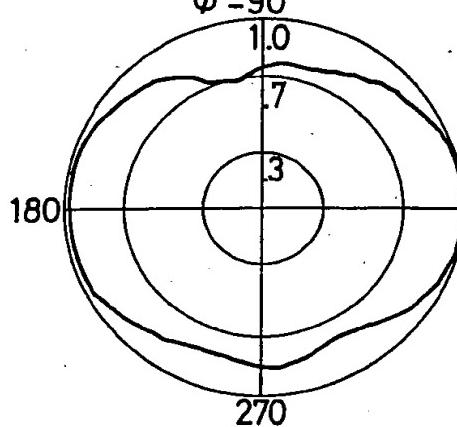
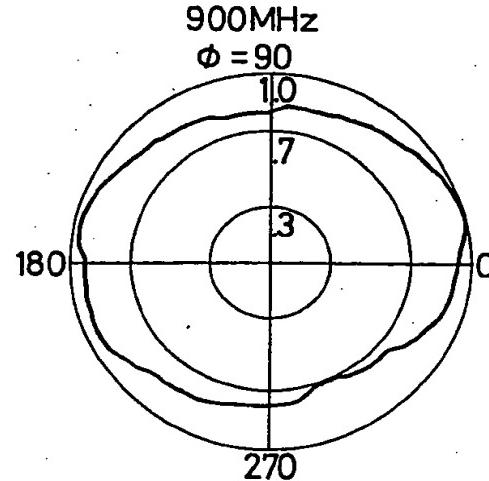
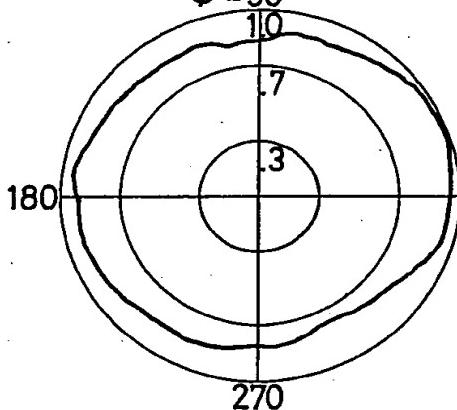
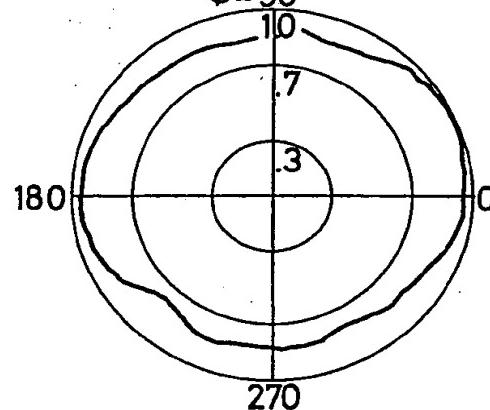
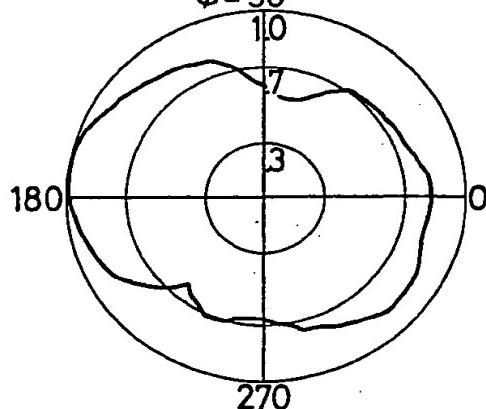
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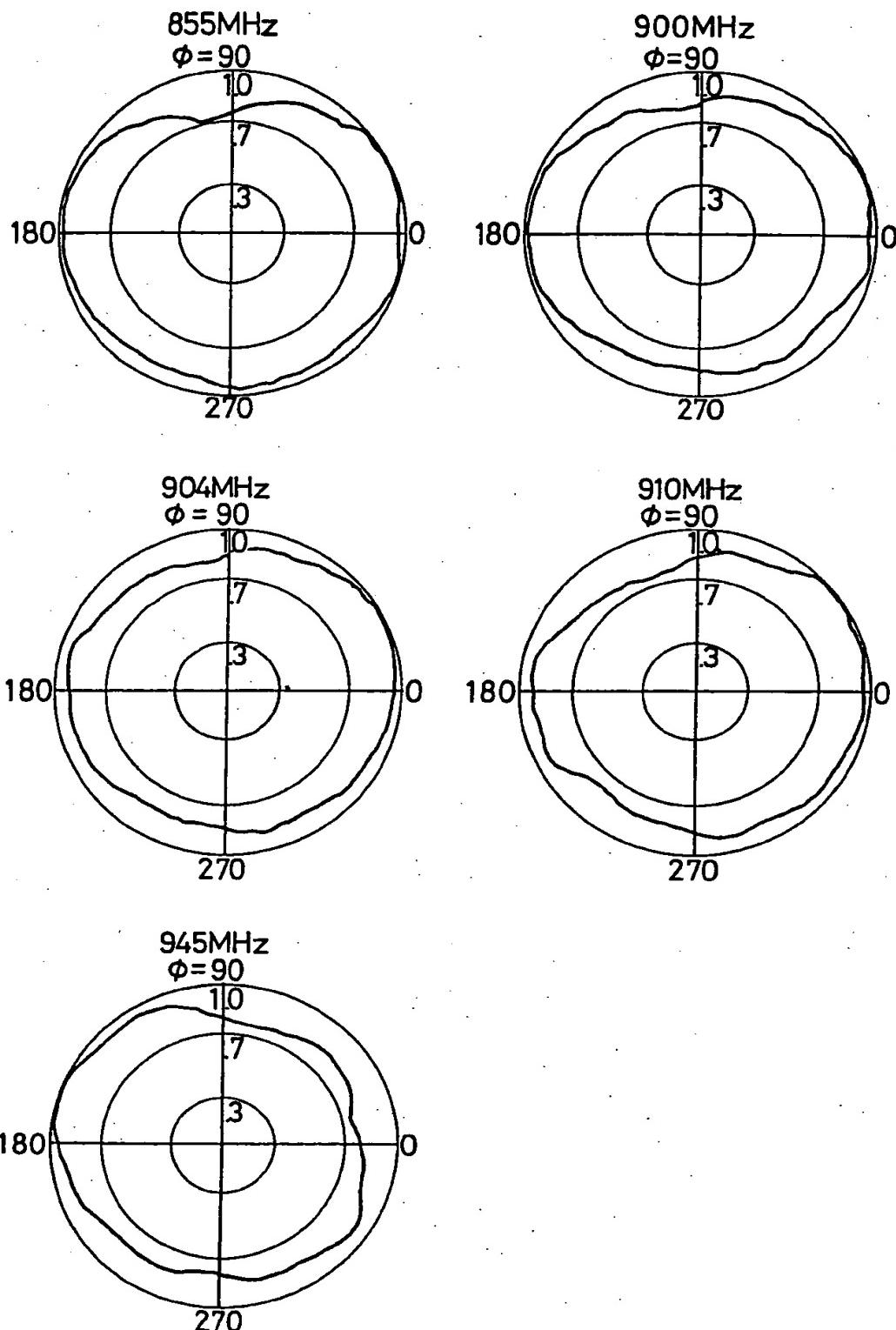
**FIG.3**

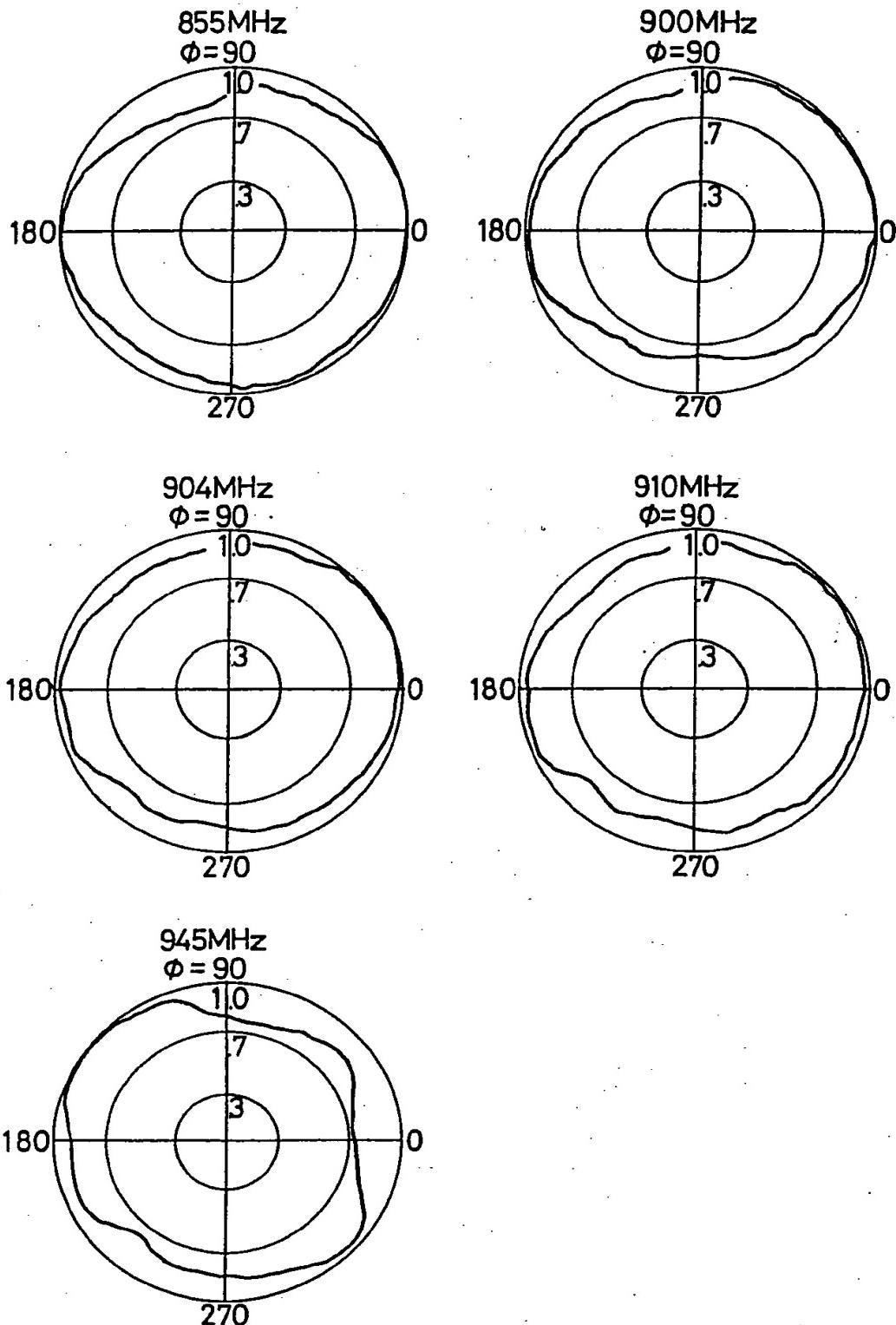


**FIG.4**



**FIG.5A**  
**(TYPE A)**855MHz  
 $\phi = 90$ 900MHz  
 $\phi = 90$ 904MHz  
 $\phi = 90$ 910MHz  
 $\phi = 90$ 945MHz  
 $\phi = 90$ 

**FIG.5B  
(TYPE C)**

**FIG. 5C**  
**(TYPE E)**

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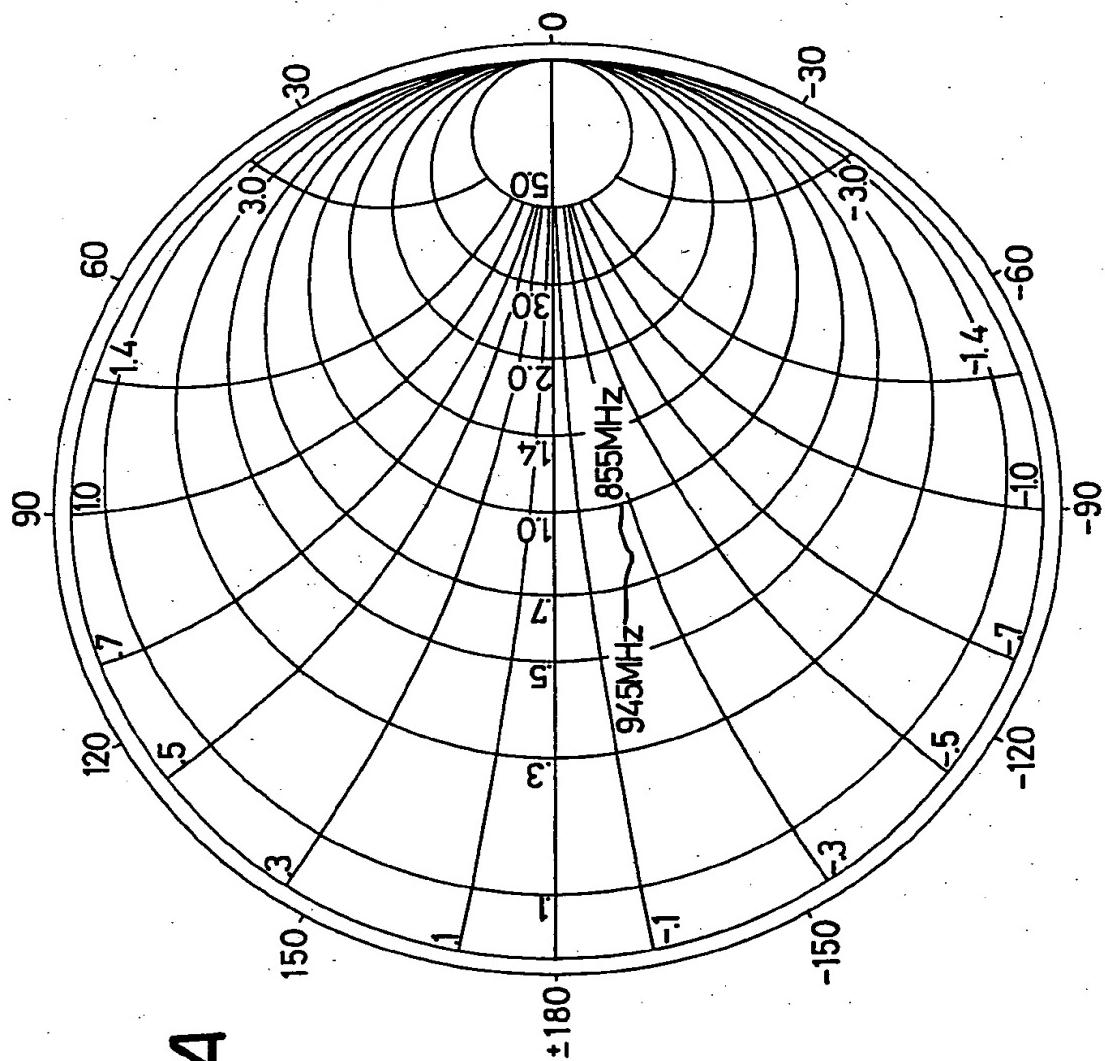


FIG. 6A

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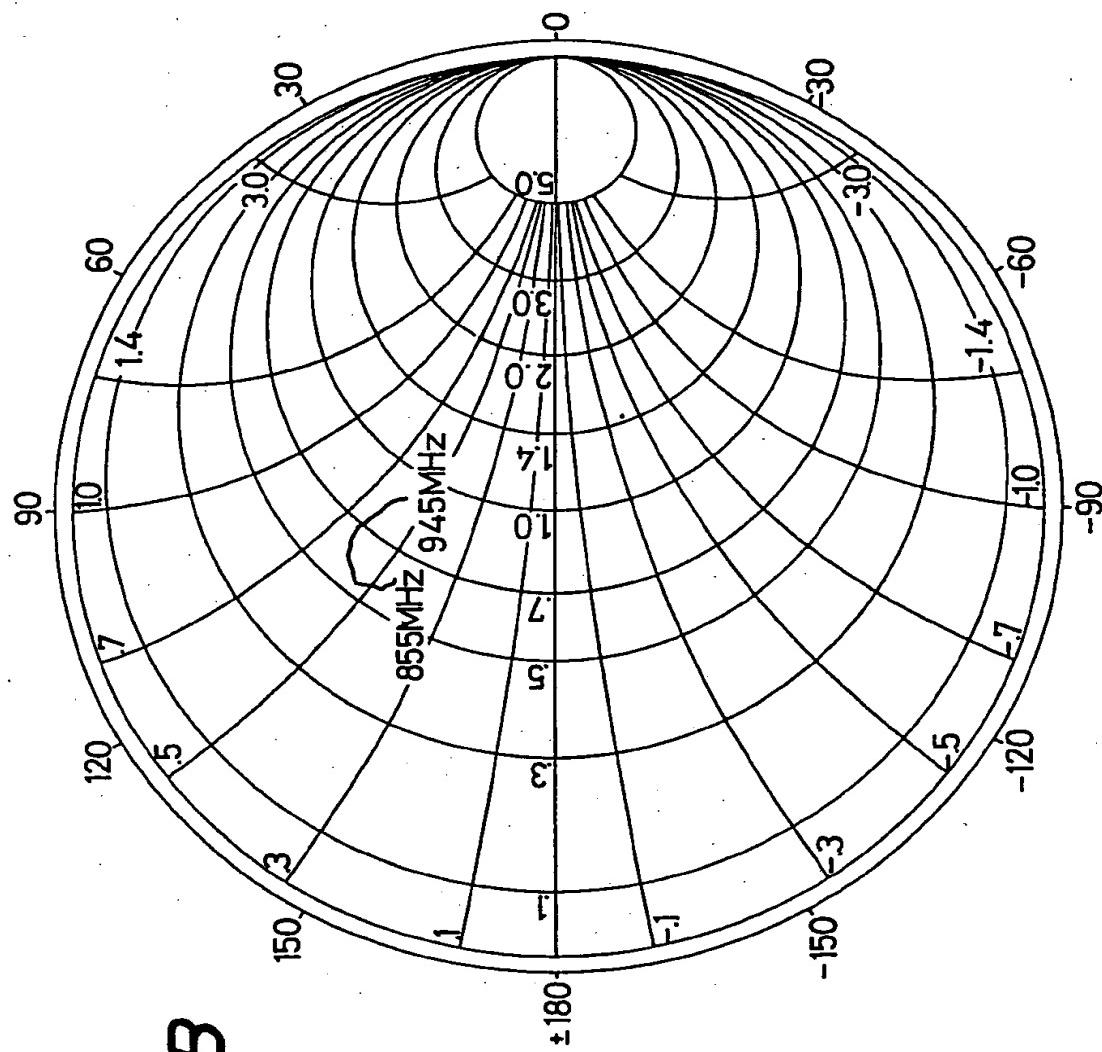


FIG. 6B

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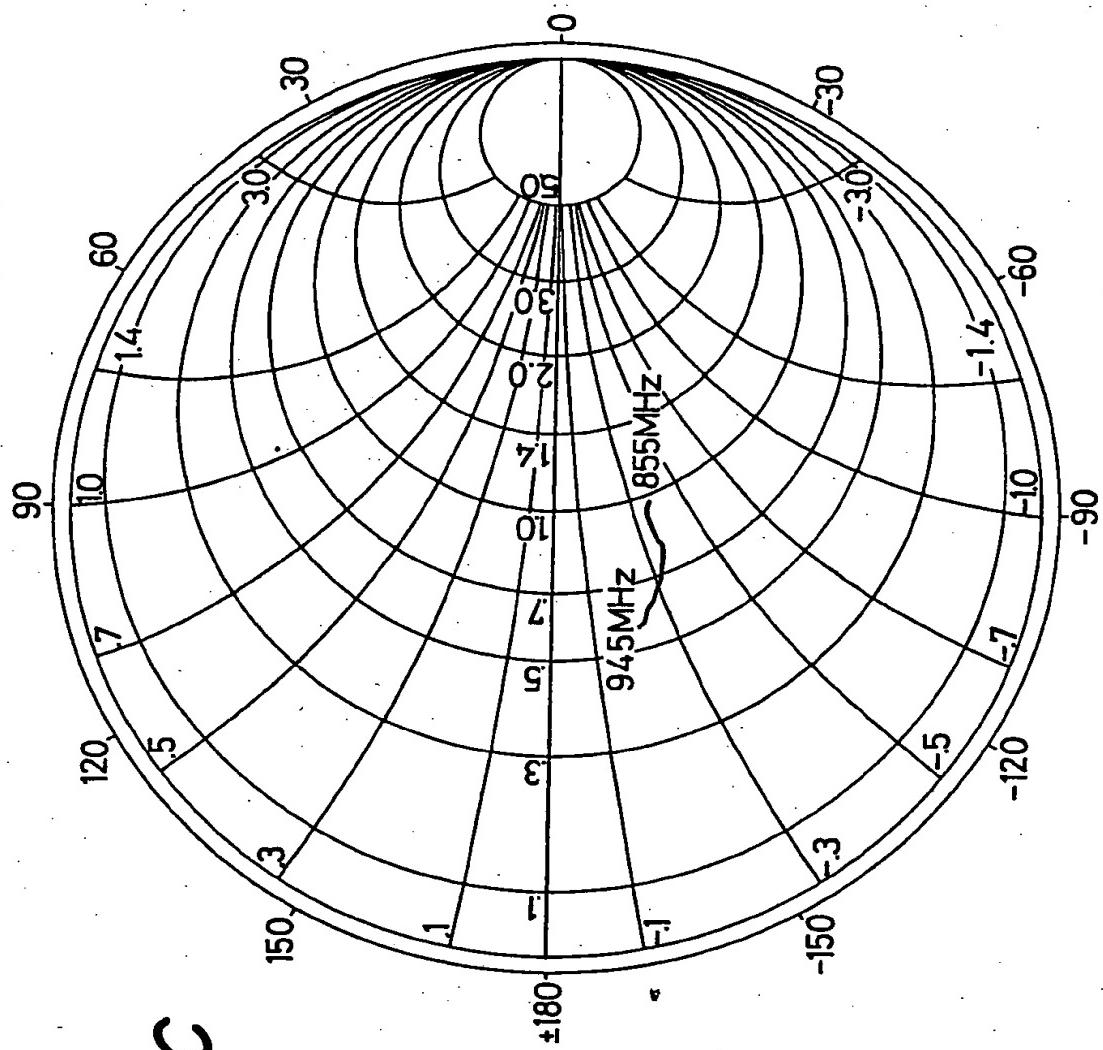


FIG. 6C

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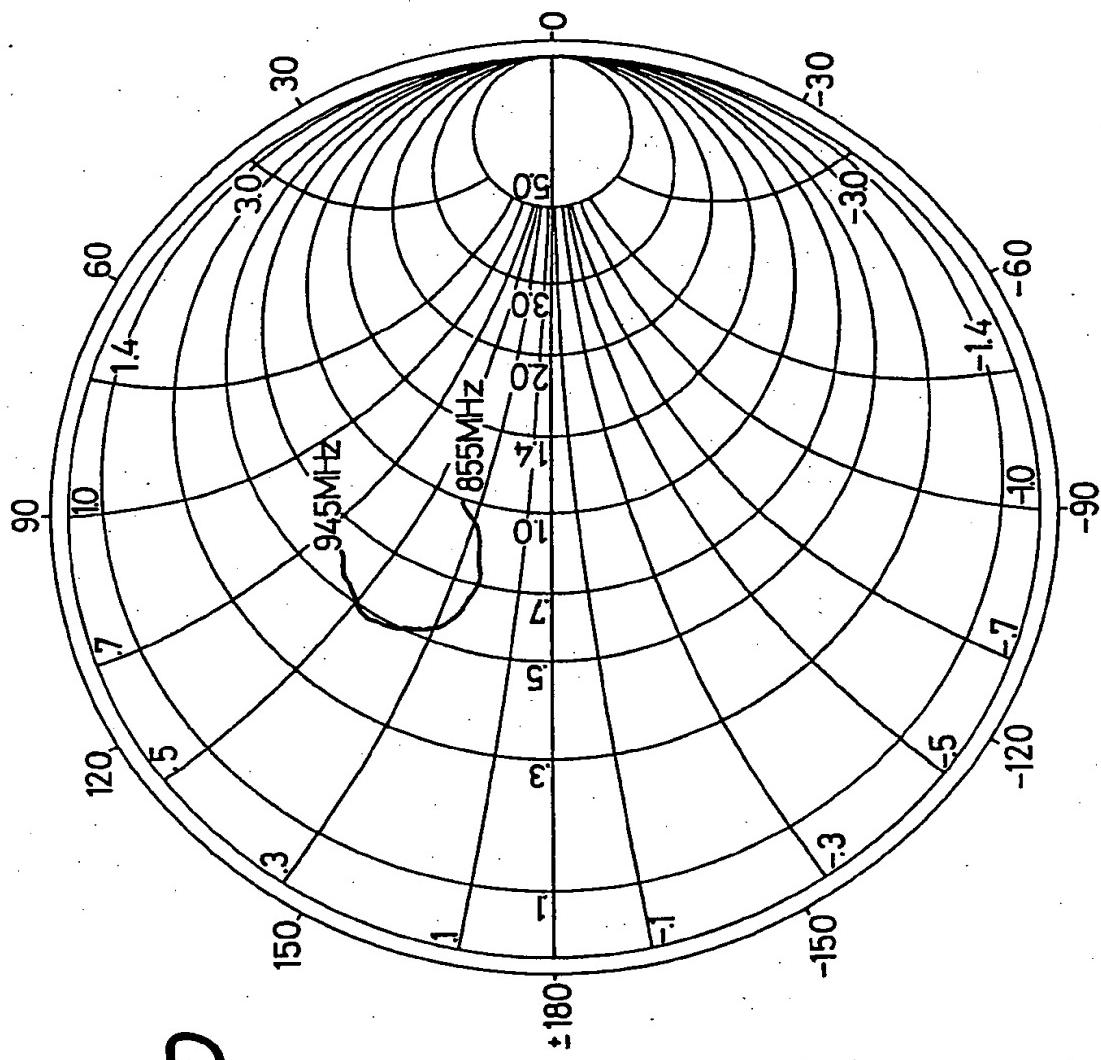


FIG. 6D

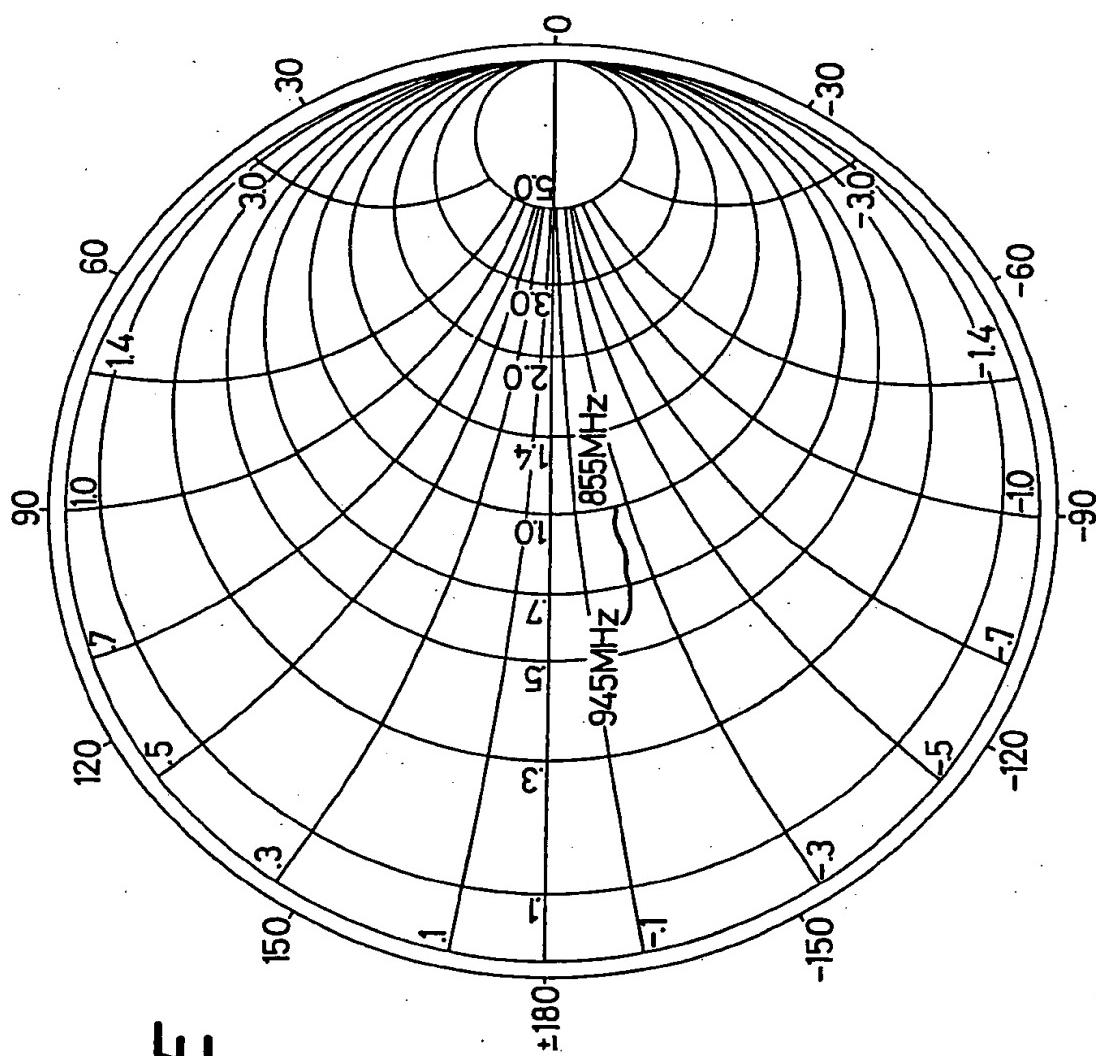
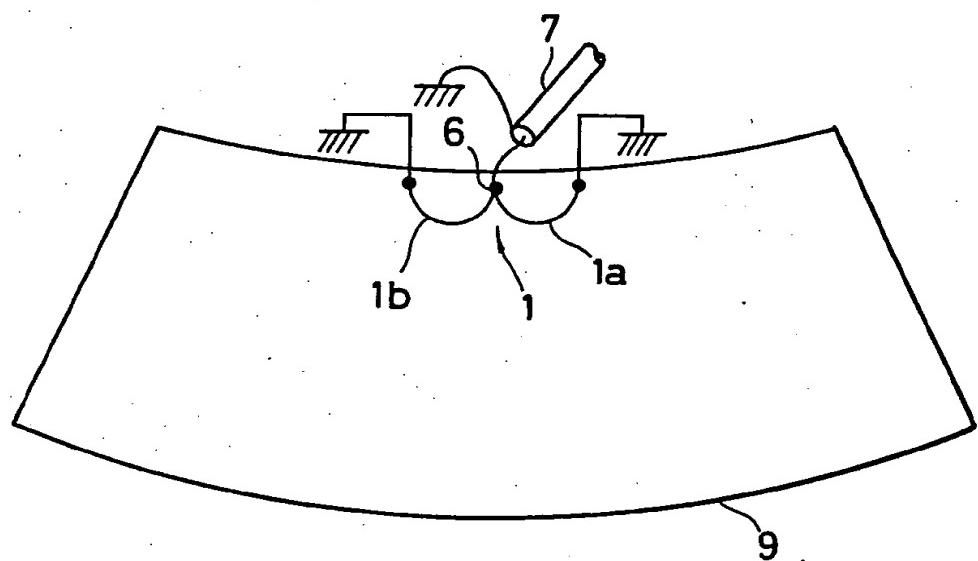


FIG. 6E

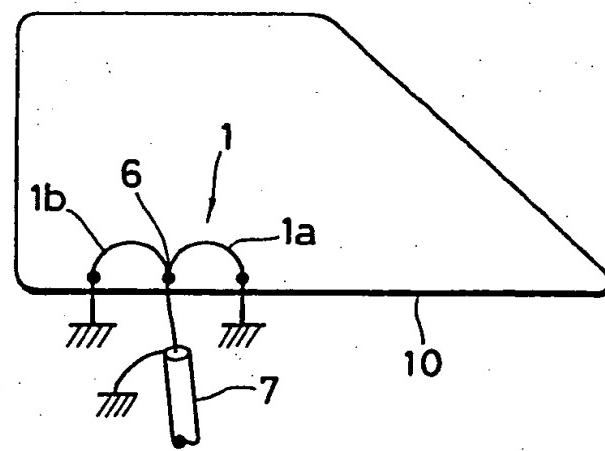
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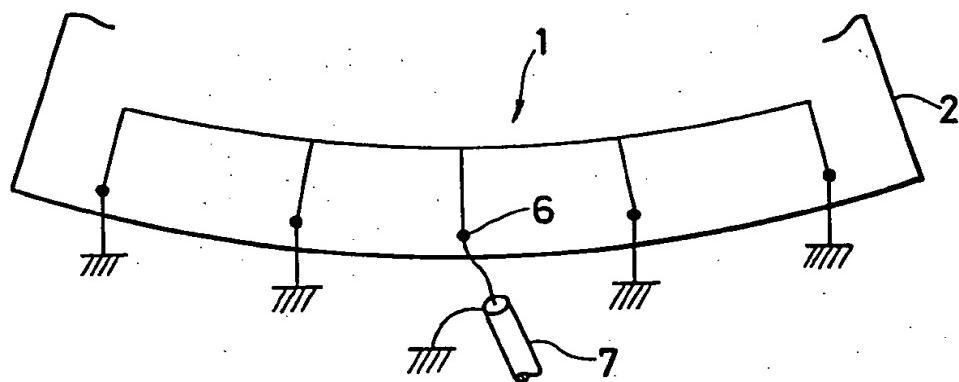
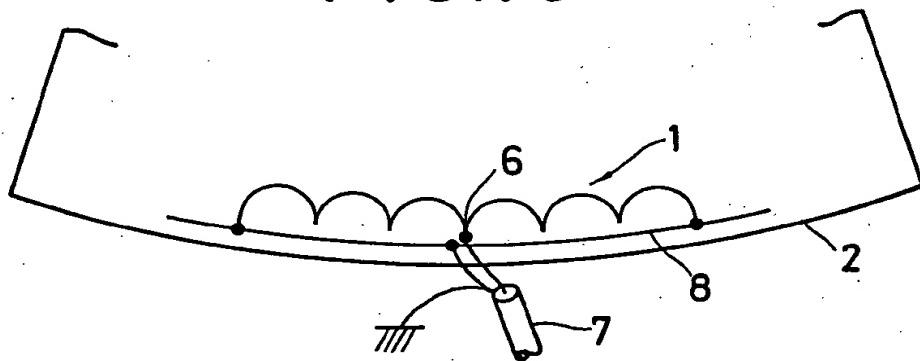
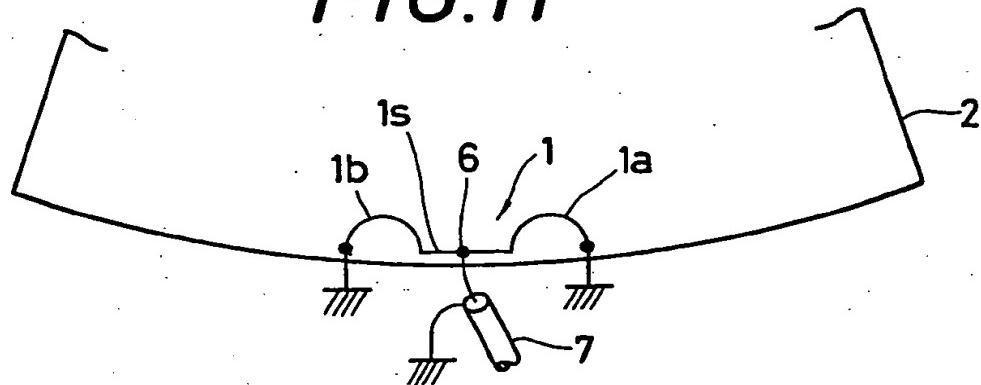
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**FIG. 7**



**FIG. 8**



**FIG.9****FIG.10****FIG.11**

**SPECIFICATION****A window antenna for a vehicle**

- 5 The present invention relates to a window antenna for a vehicle and, more particularly, to a window most suitable for a transmission/reception antenna used for a vehicle telephone or for a personal radio communication set.

*Description of the prior art*

- 10 Conventionally, a rod antenna arranged on a hood, roof, or boot is used for a transmission/reception antenna for a vehicle telephone or for a personal radio communication set. Since the transmission band normally used falls in the range of 800 MHz to 900 MHz, a multistep (three or six steps) non-directional colinear rod antenna is often used.  
 Such a rod antenna is often damaged or stolen. In particular, since the colinear antenna cannot easily be given an extendible structure unlike a rod antenna used for reception of radio programs, it cannot be housed in a hood or boot space when it is not used. When a vehicle carrying a colinear antenna is to be washed in an automatic car washer, the colinear antenna must be removed.

15 The present invention arises from the consideration of the above situation and has as its object the provision of a transmission/reception antenna which has good characteristics in a UHF band (several hundreds of MHz to several thousands of MHz) and is in the form of a window antenna.

20 According to the present invention, there is provided a window antenna which is arranged on the window glass of a vehicle and comprises a pair of antenna elements branching from a feed point adjacent to a grounded conductor portion, such as a window frame or a body frame, therealong laterally in both directions. Each antenna element comprises at least one semiloop element of a length of  $\lambda/2$  having an opening portion 25 facing the grounded conductor portion. The semiloop element may have a semicircular shape. The terminals of the antenna elements are grounded and the feed point is provided with unbalance feeding to perform transmission or reception.

25 A closed loop antenna is constituted by utilizing the grounded conductor portion, such as a window frame. The window antenna of the present invention occupies a small area although it can provide high performance.

**30 Brief description of the drawings**

Figure 1 is a front view of a rear-window antenna comprising a window antenna for a vehicle according to an embodiment of the present invention;

- 35 Figure 2A is a schematic diagram showing a basic arrangement of an antenna pattern;  
 Figures 2B to 2E are schematic diagrams showing modifications of the basic pattern shown in Figure 2A;  
 Figure 3 is a graph showing the frequency-gain characteristics of an antenna wire 1 shown in Figure 1;  
 Figure 4 is a graph showing the frequency-gain characteristics of a conventional rear pole antenna;  
 Figures 5A, 5B, and 5C are graphs showing directivities corresponding to the antenna patterns shown in Figures 2A, 2C, and 2E;  
 40 Figures 6A to 6E are Smith charts corresponding to Figures 2A to 2E; and  
 Figures 7 to 11 are diagrams showing modifications of antenna locations and antenna shapes.

*Detailed description of the preferred embodiments*

45 As shown in Figure 1, a transmission/reception antenna wire 1 used for a vehicle telephone or a personal radio communication set is formed on the inner surface of a rear window glass 2 by printing and baking a conductive paste together with a defogging heater wire 3 and an FM/AM antenna wire 4. The antenna wire 1 is tuned to transmit and receive a vertically polarized wave falling within the range of 800 MHz to 900 MHz with high performance.

50 Figure 2A shows the basic arrangement of an antenna pattern. As shown in Figure 2A, semicircular semi-loop antenna elements 1a and 1b are symmetrically branched from a feed point 6, and their terminals 1c and 1d are grounded. The feed point 6 is unbalanced fed with power by a coaxial feeder 7, whose shield conductor is grounded. The feed point 6 and the terminals 1c and 1d of the elements 1a and 1b are arranged substantially in line. As shown in Figure 1, the entire antenna wire 1 is arranged adjacent to a body frame 5, i.e., a grounded conductor portion of a vehicle along the bottom side (window frame) of the rear window glass 2.  
 55 The terminals 1c and 1d are connected to an adjacent frame through a lead wire or a conductive leaf spring.

The length of the semicircular antenna elements 1a and 1b substantially corresponds to  $\lambda/2$ . In practice, since a specific band is used for transmission or reception,  $\lambda$  is determined so as to correspond to a specific frequency at substantially the center of the band while taking a shortening ratio into consideration. In the embodiment in Figure 2, the specific frequency is 900 MHz, and  $\lambda/2$  is 167 mm, and a radius of the semicircular element is 53 mm.

60 A current fed to the feed point 6 flows through the frame 5 (grounded conductor) from the terminals 1c and 1d of the elements 1a and 1b and is then returned to an outer conductor of the coaxial feeder 7. Therefore, assuming that a semicircular image current symmetrical with each of the elements 1a and 1b flows through the frame, it can be considered that a double-loop antenna, each circumference of which substantially corresponds to a wavelength, is formed. However, since the semicircular conductors are provided in practice,

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a high-performance loop antenna can be arranged on the window glass within a small area. In particular, since the heater wire 3 and the FM/AM antenna wire 4 are arranged on the rear window glass 2, as shown in Figure 1, a transmission/reception antenna for a vehicle telephone can be mounted by skillfully using a remaining small area on the glass 2.

- 5 Figure 3 is a reception gain graph of the rear window antenna wire 1 shown in Figure 1. As can be seen from Figure 3, substantially flat characteristics can be obtained in the range of 850 MHz to 950 MHz. When compared with a reception gain graph of a conventional rod antenna (rear pole antenna), a decrease in gain of the window antenna of this embodiment is at most 10%.

10 Figure 5A shows directivity graphs of the antenna wire 1 of the basic pattern shown in Figure 2A made on an experimental basis, wherein gain ratios for the frequencies of 855, 900, 904, 910, and 945 MHz are plotted when maximum gains for azimuth angles 0° to 360° are normalized to 1. As shown in Figure 5A, nondirectional characteristics having no extreme peak or dip portion can be obtained.

15 Figure 6A is a Smith chart of the antenna wire 1 shown in Figure 2A. As can be seen from Figure 6A, an impedance very close to a characteristic impedance  $Z_0 = 50 \Omega$  (normalized Impedance  $Z/Z_0 = 1.0$ ) can be obtained within the range of 855 to 945 MHz. Therefore, good matching with the feeder 7 is achieved. A change in impedance against a change in frequency is also eliminated.

20 A standing wave ratio (SWR) falls within a range of 1.2 to 1.7, as shown in the column of Type A in Table 1 below. As can be understood from Table 1, good matching performance can be obtained.

20 *Table 1. Standing wave ratio*

Antenna type		SWR
25	A	1.2 to 1.7
	B	1.9 to 2.5
	C	1.3 to 1.8
	D	1.6 to 3.0
	E	1.2 to 1.7

30 Type A in Table 2 below corresponds to frequency-gain characteristics of the antenna wire of the basic pattern shown in figure 2A made on an experimental basis. As can be seen from Table 2, a flat gain can be obtained in the range of 855 to 945 MHz as in the graph shown in Figure 3. For the purpose of comparison, Table 2 also shows frequency-gain characteristics of a vertical element having a length of  $\lambda/4$  formed as the window antenna which is provided with unbalanced power feed so as to operate virtually as a  $\lambda/2$  dipole 35 antenna.

35 *Table 2. Maximum gain*

40	Antenna	$\lambda/2$ Dipole Antenna	Type A	Type C	Type E
	855 MHz	34.6 dB	40.0 dB	40.5 dB	40.5 dB
	900 MHz	37.8 dB	35.2 dB	40.0 dB	39.7 dB
45	904 MHz	40.0 dB	40.1 dB	43.8 dB	43.5 dB
	910 MHz	38.8 dB	39.8 dB	40.0 dB	40.5 dB
	945 MHz	33.3 dB	35.0 dB	36.4 dB	35.1 dB

50 Figures 2B to 2E show the modifications of the basic antenna pattern A. In an antenna of type B, a pair of semicircular elements 1e and 1f are added to the left and right sides of the antenna of type A, and their terminals 1g and 1h are grounded. In an antenna of type C, intermediate points 1c and 1d (nodes) of type B are grounded. In an antenna of type D, semicircular elements 1i and 1j are added to the antenna of type C, and their terminals 1k and 1l are grounded. In an antenna of type E, intermediate points 1c, 1d, 1g and 1h are grounded. In these modifications, an antenna conductor length is an even integer-multiple of  $\lambda/2$ .

55 Figures 5B and 5C show directivities of the antennas of types C and E, and Figures 6B to 6E are Smith charts for the antennas of types B to E shown in Figure 2. Table 1 shows the standing wave ratios of respective types B to E, and Table 2 shows frequency characteristics of the antennas of types C and E. From these data, the antenna wires of types B to E can provide high performance substantially the same as or superior to that of type A.

60 Figure 7 illustrates a case wherein the antenna wire 1 of type A is added to a front window glass 9 of a vehicle, and is arranged along the upper side of the window glass 9 so as not to interfere with the field of view of a driver. Figure 8 shows a case wherein the antenna wire 1 is arranged on a rear quarter window 10.

65 Figure 9 shows a case wherein each semicircular semiloop shown in Figure 2 is modified to be a rectangular semiloop. In this case, it is also preferable that the conductor length of the respective rectangular semiloops is set to be about  $\lambda/2$ .

65 Figure 10 illustrates a case wherein a ground wire 8 is arranged along the lower portion of the semicircular

element array, and the terminals are grounded therethrough. Since grounding of the two terminals and the intermediate points, if necessary, can be achieved by grounding the wire 8 to a point on the frame of to a shield conductor of the coaxial feeder 7, the grounding structure can be simplified.

Figure 11 shows a modification of the basic pattern, in which a pair of semicircular elements 1a and 1b are separated at a given distance in the horizontal direction. It is preferable that the distance between the two elements (the length of a straight line portion 1s) is about  $\lambda/2$ . A plurality of semicircular elements can be added to this modified pattern, as shown in Figures 2B to 2E.

In the above embodiments, a pair of antenna elements are symmetrical with each other, but can be asymmetrical by differing the lengths of the respective elements in order to achieve broad-band reception and transmission.

According to the present invention, a high-performance nondirectional transmission or reception antenna for the UHF band having good matching performance with characteristic impedance can be arranged on a window glass of a vehicle within a small area.

## 15 CLAIMS

1. A window antenna arranged on a window glass of a vehicle, comprising:  
a pair of antenna elements branching from a feed point adjacent to a grounded conductor portion laterally therealong in both directions.
- 20 each antenna element comprising at least one semiloop element of a length of  $\lambda/2$  having an opening facing the grounded conductor portion, and  
terminals of said antenna elements being grounded and said feed point being provided with unbalance feeding.
- 25 2. A window antenna according to claim 1, wherein said antenna is a transmission/reception antenna for a vehicle telephone, and has a conductor length tuned in a UHF band.
- 30 3. A window antenna according to claim 1, wherein said antenna is arranged on a rear window glass of a vehicle together with a defogging heater wire and a radio reception antenna wire.
4. A window antenna according to claim 1, further comprising an unbalanced power-feed coaxial feeder wire, a core conductor of which is connected to said feed point, and an outer conductor of which is grounded.
- 30 5. A window antenna according to claim 1, wherein said semiloop element is a half of a circular loop.
6. A window antenna according to claim 1, wherein the grounded conductor portion is a body of a vehicle.
7. A window antenna according to claim 1, wherein said antenna elements comprise a plurality of series-connected semiloop elements, and terminals of the leftmost and rightmost elements are grounded.
- 35 8. A window antenna according to claim 1, wherein said antenna elements comprise a plurality of series-connected semiloop elements, and terminals of the respective elements are grounded.
9. A window antenna according to claim 1, wherein said antenna elements are arranged along an upper side of a front window of a vehicle.
10. A window antenna according to claim 1, wherein said antenna elements are arranged on a rear quarter window of a vehicle.
- 40 11. A window antenna according to claim 1, wherein said semiloop element is a half of a rectangular loop.
12. A window antenna according to claim 1, wherein said grounded conductor portion is a grounded conductive wire arranged on a window glass along said antenna elements.
13. A window antenna according to claim 1, further comprising a linear conductor wire having a length of about  $\lambda/2$  for connecting said pair of antenna elements at its ends, said feed point being arranged at an intermediate point of said linear conductive wire.

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